PROGRESSIVELY VARYING FOCAL POWER OPTHALMIC LENS

This is a continuation-in-part application of Ser. No. 121,774 filed on Feb. 14, 1980 now abandoned.

TECHNICAL FIELD

The present invention relates generally to the field of ophthalmic lenses, and, more particularly, to ophthalmic lenses having a progressively varying focal power.

BACKGROUND ART

Presbyopia is a term used to refer to the condition of reduced or defective elasticity of the crystalline lens of the eye. It is an ailment that eventually affects most people, usually around middle age, and it is characterized by the inability of the eye to attain a sharp focus for near vision.

Traditionally, the treatment for presbyopia has been to prescribe corrective ophthalmic lenses having two or more spherical surfaces or segments of different refractive power. In particular, these lenses, known as multifocal lenses, are designed such that the power of one segment will permit proper focusing on nearby objects while the other segment or segments will correct the vision for viewing objects at greater distances. Typically, a person suffering from presbyopia will initially wear lenses having two segments known as bifocals, and, as the eye further deteriorates, may later require lenses having three segments, called trifocals, to assist in focusing on objects at intermediate distances.

Multifocal lenses have been in use for a great many years and are generally quite acceptable insofar as their ability to provide improved vision. They do, however, suffer from several inadequacies. For one thing, conventional multifocal lenses have a sharp dividing line or discontinuity between the various segments of the lens, and, when the line of sight scans across this dividing line, a jump usually occurs in the image perceived by the wearer. For many wearers, it is difficult to adjust to this sensation.

Also, many patients, particularly those having severely reduced powers of accommodation (the ability of the eye to automatically adjust for viewing objects at different distances is referred to as "accommodation"), are unable to clearly focus on objects that lie between those distances for which the various segments of the lens are designed to focus.

Finally, many people having reduced accommodation powers are hesitant to wear multifocal lenses because of their belief that it detracts from their appearance and suggests to others that they are growing old. Such people, although they may require corrective spectacles, will not wear them, at least not regularly, and thus are not only sacrificing good vision but are also creating a safety problem as, for example, driving without proper glasses.

Recognizing the inadequacies of conventional multifocal lenses, a new type of lens has been introduced into the marketplace in recent years. These lenses are generally known as progressively variable focal power lenses or, more simply, as progressive power lenses, and they are designed to provide multifocal lens characteristics without any sharp dividing line or discontinuity between the various portions of the lens. Specifically, such lenses are characterized by having a progressive power portion positioned between and merging into the distance and reading portions of the lens. Furthermore, the progressive portion is designed to have a continuously varying focal power beginning with a focal power equal to that of the distance portion where it merges with and into the distance portion and ending with a focal power equal to that of the reading portion where it merges into the reading portion of the lens.

These three portions, the distance, reading and progressive power portions, constitute the functional zone of the lens, and this zone provides corrective optical powers defined by prescription. The remaining area of the lens constitutes the peripheral zone which is usually strongly aberrated and does not provide proper corrective power for the wearer.

The basic patent for this type of lens was issued in 1915 (U.S. Pat. No. 1,143,316) and a more refined version was issued in 1924 (U.S. Pat. No. 1,518,405). Both patents dealt mainly with the functional zone of the lens. The numerous patents issued subsequently provided different formulations for the peripheral zone, aiming at reducing the aberrations or dealing with manufacturing methods or both. The introduction of numerically controlled surface generating machines in the last decade removed many limitations that were imposed by manufacturing techniques; and, consequently, more recent patent focused on the minimization of aberrations in the peripheral zone.

Two aberrations in that zone which have a major effect on the wearer's comfort are astigmatism and distortion of horizontal and vertical lines. The physical and mathematical properties of these two aberrations are well understood by those skilled in this field, and it is recognized that due to physical requirements which have to be fulfilled in the functional zone, these aberrations cannot be completely eliminated. This limits the design objective to the development of a surface geometry having a particular distribution of aberrations in the peripheral zone so as to provide the best possible comfort to the wearer.

Particularly disturbing is the distortion of horizontal and vertical lines in the temporal peripheral zone. Also, the unavoidable astigmatic aberration is particularly offending in the zone adjacent the distance portion as it affects the near peripheral vision during distance viewing. Another undesirable place for this aberration is the lowest portion of the peripheral zone because it tends to distort true ground level perception. Typically, the more recent U.S. patents, such as U.S. Pat. Nos. 3,687,528; 3,711,191; 3,910,691; 4,055,379 and 4,062,629 are all aimed at providing the best solution for the above described conditions.

DISCLOSURE OF THE INVENTION

The present invention addresses the same design objective as above, i.e., to provide the best possible comfort to the wearer. In particular, the present invention provides a novel mathematical model for the geometry of the entire lens surface which permits a reduction of the distortion of horizontal and vertical lines in the temporal peripheral zone below detectable levels which minimizes the astigmatic aberration in the area adjacent to the distance portion and which eliminates the astigmatic aberration in the lower part of the temporal peripheral zone.

Furthermore, the present invention provides a unique geometry which allows these characteristics to be retained after rotating the lens to accommodate for the right or left eye. In particular, since the lenses have to